

Growatt Speed---- AFCI Technology for average 0.75s

Background

Safety is the top priority of production and personal life, especially for photovoltaic (Hereinafter abbreviated as PV). We found that a large number of PV fire accidents are caused by DC arcs which due to poor contact of devices, aging or damage of cables. In traditional, these problems can only be solved by improving engineering quality and manual inspection. However, these methods cannot be used to locate all the problems, and accidents may still occur occasionally. The active Arc-Fault Circuit-Interrupter (AFCI) has more accurate arc detection and faster fault elimination functions, which can solve all the problems we mentioned before and fully ensure the safety of PV plants.

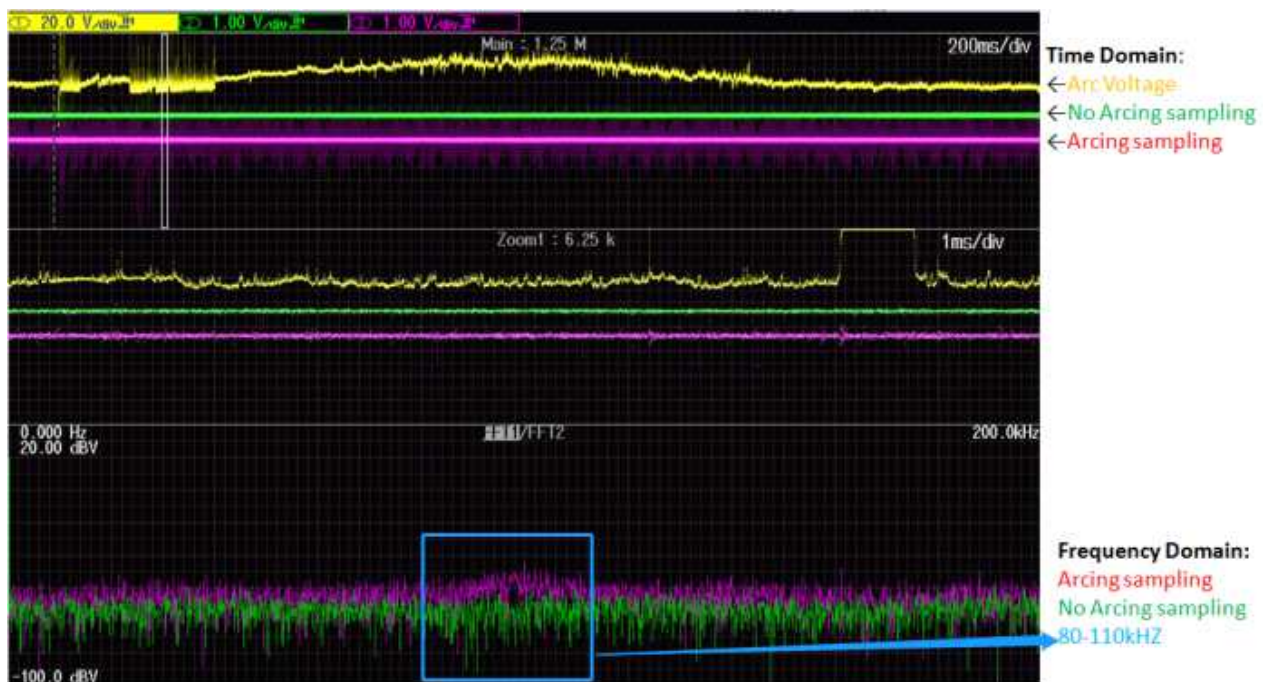
About AFCI

The main function of AFCI is to prevent fires caused by faulty arcs, such as aging, damage of electrical insulation, wires, loose connections and air breakdown caused by air humidity, etc. In 2011, the National Electrical Code (NEC) of America has developed a standard for PV arc fault protection circuit which called UL1699B, it requires the PV devices installed in buildings with voltages greater than 80 V and less than 1 kV must be installed with arc fault interrupter or relevant protection devices and comply with the standards. It requires the detection and interrupt the arc within 2.5 seconds, and limit the energy not to exceed 750 J. Growatt AFCI has been verified by authoritative certification agencies under different severe conditions. Proved by thousands of tests, the error reporting time is in line with the latest international safety regulations. The fastest response time is 0.209S and the average time is only 0.7535S, far below the international standard 2.5S.

Principle of AFCI

The types of DC arcs in PV systems can be divided into series type, parallel type and ground fault type, among which ground fault arc is a typical form of parallel type. When a loaded wire breaks under unexpected conditions, the arc generated at the break is a series fault arc; When an unexpected path happens to pass between two conductors of opposite polarity, here the accidental arc generated by the path is the parallel fault arc; In addition to the above two points, the short-circuit fault arc generated between the phase line and the ground, the grounded metal or the equipment casing is a ground fault arc. Existing PV systems are mostly long-series DC high-voltage panels with hundreds or thousands of contacts. Therefore, the most common fire causes are series fault arcs.

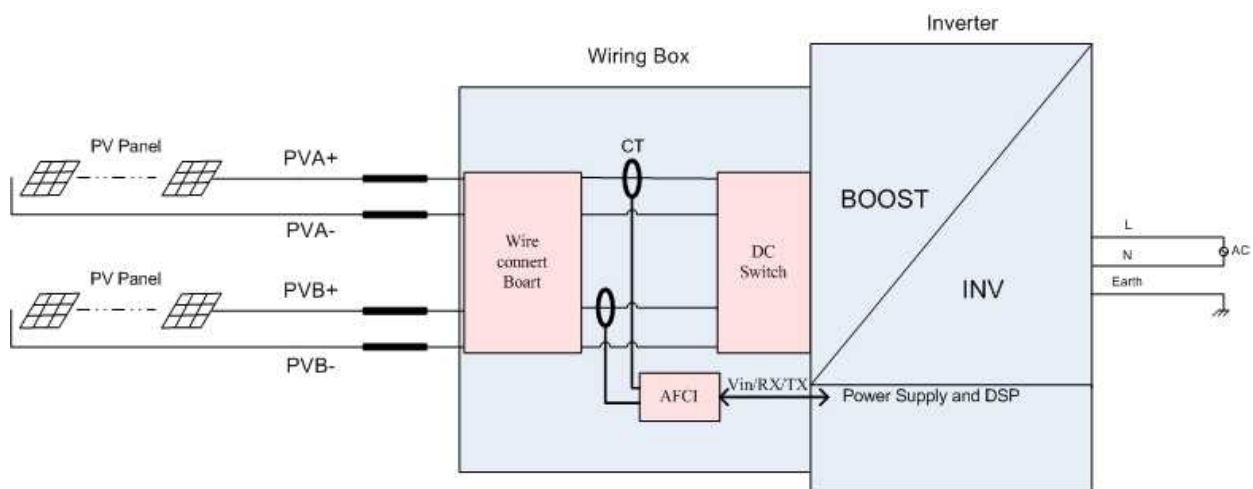
When a fault arc occurs at a certain position in the PV system, it will inevitably cause changes in the current and voltage waveforms. If the detection location is selected properly, the current and voltage waveform changes can be observed. Therefore, the current and voltage waveform changes can be used to determine whether there is a fault arc. For series fault arcs, due to the same current characteristics in the series circuit, Growatt AFCI collects changes in the input current waveform of the inverter and detects whether there is a fault arc in the loop. Through a large number of comparative experiments and data analysis, when the arc occurs, the current fluctuation increases and the dispersion of the collected current data increases (The current standard deviation becomes larger), while in normal operation, only the current average value changes suddenly in some time. Therefore, the current standard deviation can be used as one of the characteristics to determine the occurrence of a fault arc. However, the situation of on-site grid connection is changeable, only the time domain judgment may have similar waveforms and false alarms. Further research found that after the arc occurred, the harmonic component of the current in frequency domain also increased significantly (as shown below), so the arc can also be detected by frequency domain feature analysis.



Current analysis in frequency domain

Protection Principle

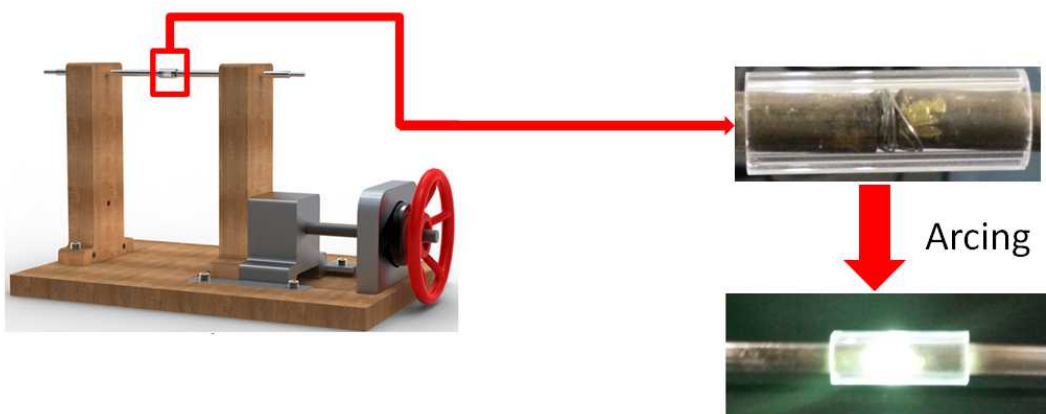
The input DC current is detected by a high-sensitivity current transformer (CT), and then the detected current signal is processed through a band-pass filter, send the processed signal to the 16-bit precision AD chip for sampling, and finally processed by MCU chip. The process of processing is to perform fast Fourier decomposition (FFT) on the data, according to the comparison between the actual normal data and the data when the arc is drawn, set a reasonable fault arc criterion, and then judge the arc. When a fault arc is detected, the alarm information is uploaded to the DSP, the inverter is controlled to cut off the arc generation path, and an error notification is promptly reported.



Inverter AFCI Structure

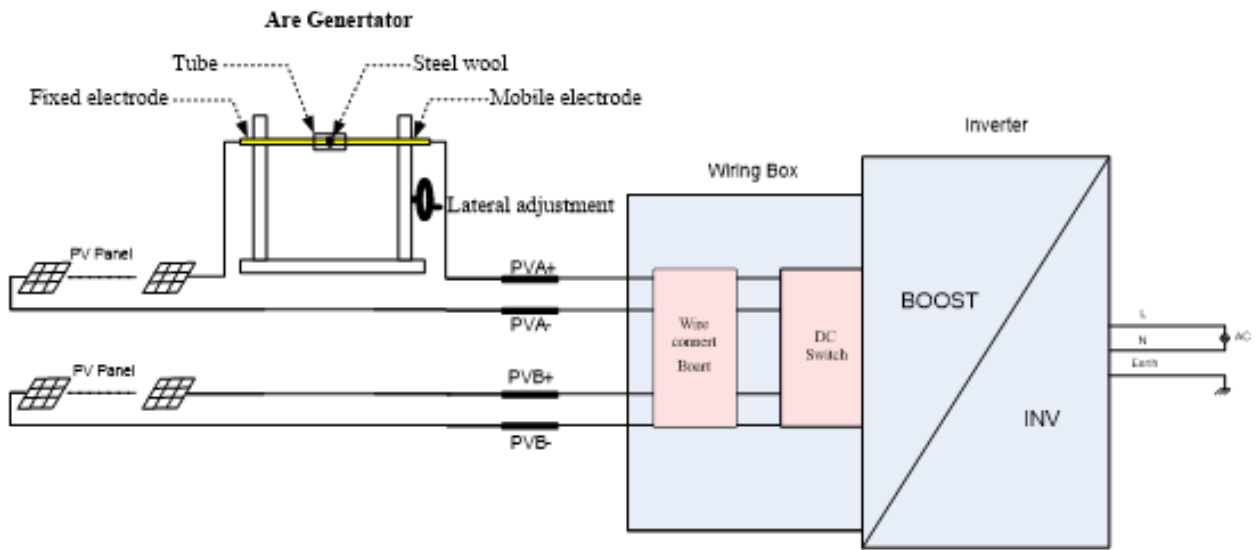
AFCI Real Test

The test method is shown below. Connect an arc generator to the PV input side and compare the results of the inverter with and without AFCI when the arc occurs.



Arc generator

1. Inverter without AFCI



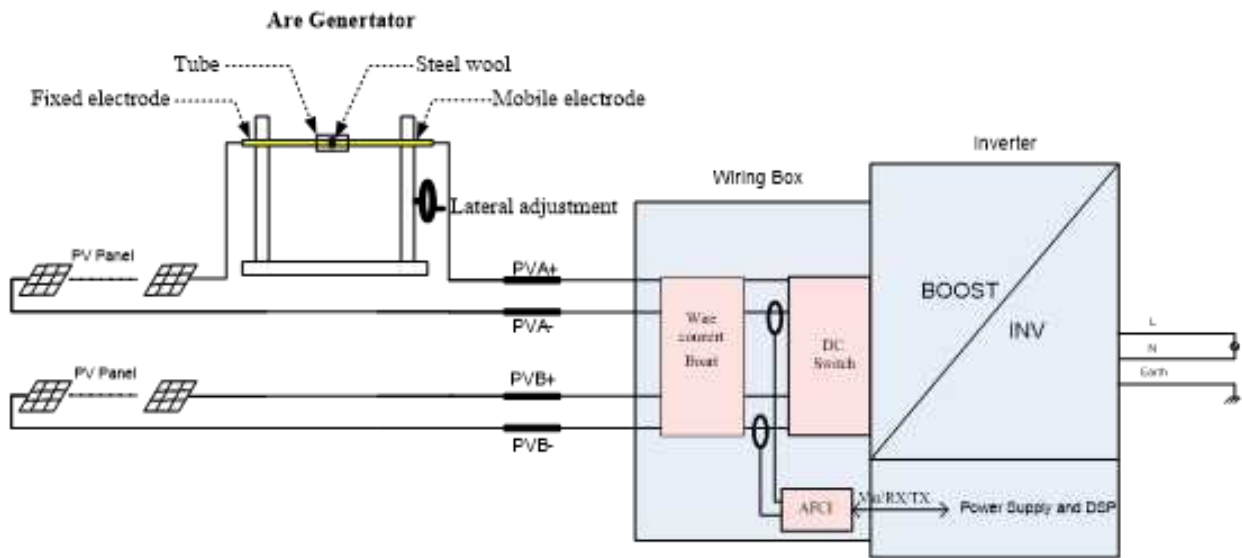
System diagram

After testing, we can see that the arc generator continues to produce an arc without extinguishing, and there is a serious fire hazard



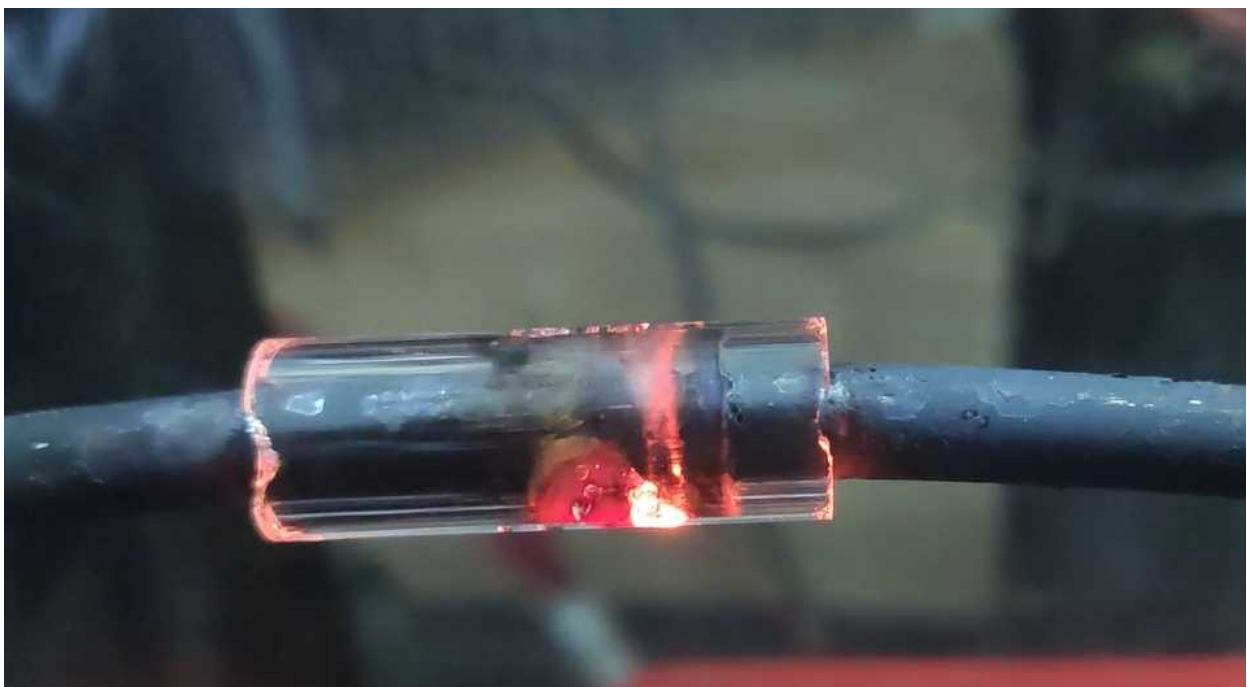
Arc continues

2. Inverter with AFCI



System diagram

AFCI detects the DC input current fluctuations in real time through the high-sensitivity mutual current transformer. When the DC arc is detected, it feeds the arc warning to the DSP, controls the inverter to cut off the arc generation path. The time does not exceed 2.5S, which effectively guarantees the safety of system.



Arc cut off

AFCI for Growatt -X series Inverters

No matter residential, commercial or utility scale, all Growatt new -X series can be integrated with AFCI function according to the need of customer. With its active detection, fast shutdown, intelligent alarm, the X series not only brings you maximum PV energy, but also provides reliable protection for your DC side, helping you to eliminate possible fire hazards to the greatest extent.



Growatt -X series inverters

Growatt AFCI---Fast & Smart

In order to meet the needs of different customers, Growatt AFCI also has the following functions under the premise of meeting the basic functions of the latest international safety regulations.

1. Fast and easy AFCI switch, you can turn on/off AFCI with one click according to your own needs at different scenes.
2. Quick test of the module, set AFCI self-check, feedback result within 30S.
3. The circuit arc is detected every 93ms, and the average time is only 753ms, which is far below the international safety standard 2.5s and the fastest test response is only 209ms.
4. AFCI reset function, one-click reset after trouble shooting on site to avoid loss of power generation.
5. AFCI real-time intensity scanning function, this function allows professional customers the opportunity to analyze the actual situation on site.

Various types of AFCI control methods

No matter in ShinePhone, ShineBus or OSS system, customers can do the setting for AFCI functions. In these platforms, you will find it including AFCI switch, self-check, reset and curve scanning functions.

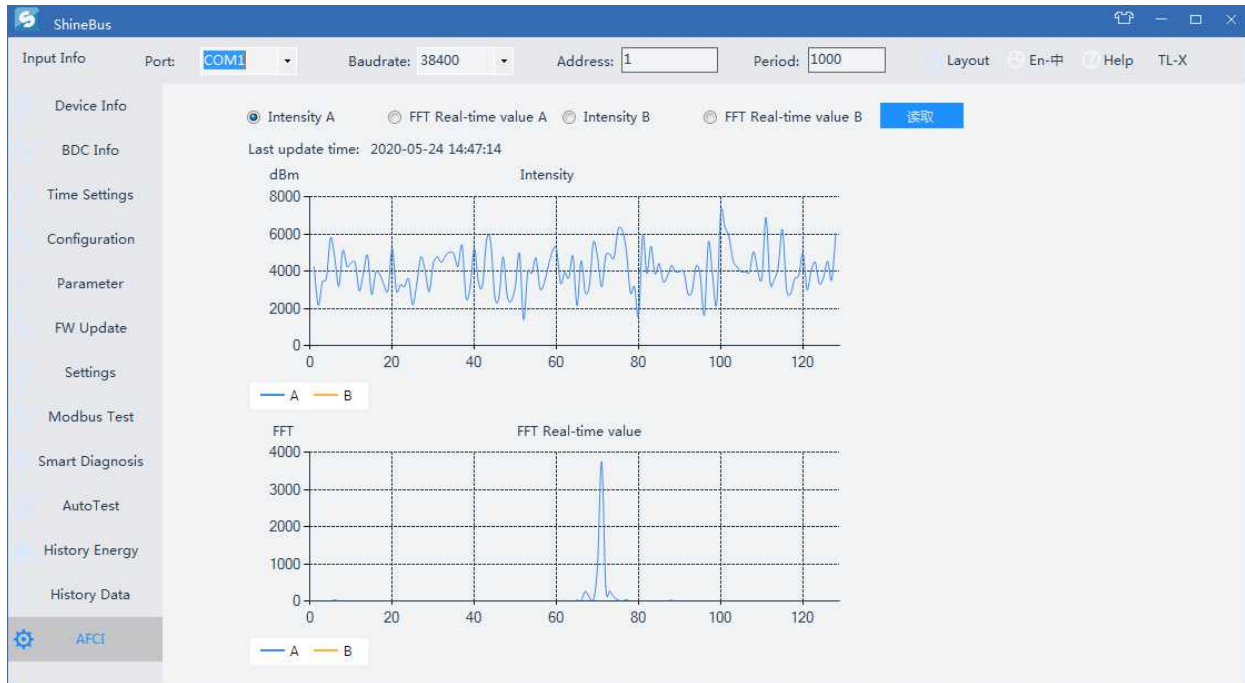
1.ShinePhone(Smart phone APP)

AFCI functions in ShinePhone



AFCI Setting page (ShinePhone)

2.ShineBus(Computer platform, need RS485 connection) AFCI functions in ShineBus



3.OSS (Distributor/Installer management system)

3.1. AFCI functions in OSS system

The screenshot shows the Growatt OSS Management System interface. The main area is titled 'After Sales Maintain' and includes a server selection dropdown (China Server selected), a search bar, and a table of inverters. A 'Set MAX' dialog box is open, displaying configuration options for AFCI functions. The dialog includes fields for 'Point2(PowerPercent,PFLinePoint)', 'Point3(PowerPercent,PFLinePoint)', and 'Point4(PowerPercent,PFLinePoint)', each with a value of 0.0. Below these are radio buttons for 'register', 'Set PV on/off' (selected), and 'User PF line'. The 'User PF line' dropdown menu is open, showing options: 'AFCIEnable', 'AFCISelf-test', and 'AFCIReset'. The dialog also includes a 'Read' button and a legend for 'PowerPercent:(0~100,255); PFLinePoint:(-1~-0.7,0.7~1);'.